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# SOME FACTORS CONCERNED WITH THE USE OF AIR-BLAST SPRAY EQUIPMENT ON POTATOES[1]

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Recent advancements in spraying for diseases and insect control have been toward the use of small quantities of concentrated spray mixtures. This has been accomplished by the use of aerial equipment, low pressure weed type sprayers and mist blowers (5), (7), (9).

Within the last 4-8 years considerable emphasis has been placed on air-blast machines and their adaptability to row crops. Unique problems in deposition and distribution have been presented and it has been pointed out that certain requirements must be attained before such machines can be used successfully. These are: air volume sufficient to replace air in the plant zone; velocity sufficient to agitate and expose all leaf surfaces to the mist; velocity sufficient to be unaffected by surface winds; and volume and velocity to be of such magnitude as to not injure succulent tissues at close range (6).

Such machines increase the speed of operation, increase rate and ease of coverage, avoid necessity of handling large volumes of water and heavy equipment, and decrease labor (4), (8). Recent performance of such equipment on row crops has given evidence of satisfactory insect control in some areas (2), (10). As a result, air-blast machines are being purchased for row crop spraying in many important vegetable regions. However, further information on factors affecting deposit patterns and pest control on potatoes with different air-blast machines is necessary.

Experiments were undertaken in 1953, 1954 and 1955 on Long Island, New York to determine some of the factors concerned with the operation of air-blast sprayers. By means of copper deposit patterns, information was obtained on the effects of such factors as plant height, swath width, nozzle arrangement and wind on overall coverage and on location within the row for individual row coverage.

## Methods and Materials

Four commercially available row crop semi-concentrate air-blast sprayer attachments were tested in these experiments.

1. A Myers Field Crop Concentrate Attachment No. 52CA-F29 (22 rows) was modified by the addition of a fixed deflector placed on the top of the one sided discharge outlet with a 20 degree downward angle to direct the air stream. Also, a second nozzle was added outside of the air-blast to aid in covering one wheel row. The regular nozzle arrangement consisted of 10 Myers nozzles fitted in the vertical discharge manifold with either no. 3 or no. 5 porcelain discs and 2 hole whirl plates. The modified arrangement consisted of 10 nozzles fitted from top to bottom as follows: 2 with no. 5 discs and 3 hole whirl plates 2 with no. 3 discs and 3 hole whirl plates, 1 with no. 5 disc and 2 hole whirl

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plate, 4 with no. 3 discs and 2 hole whirl plates and 1 with no. 5 disc and 2 hole whirl plate. The two nozzles used to spray the one row under the machine contained no. 3 discs and 2 hole whirl plates.

2. A Hurst-Cardox Aqua-Jet Blower Attachment was modified by the addition of two fixed deflectors attached to the top of the two sided discharge housing at a 40 degree angle to aid in directional control of the air stream. Three special, adjustable, impingement nozzles were mounted on each side of the housing but only two were used in order to reduce discharge volume. The rows straddled by the machine were covered by the swirl-back of the air stream under the machine. No nozzle provisions were made to spray these rows.

3. A Bean Speedair Model 12-RC (28 rows) with two sided discharge manifold consisted of 7 nozzles arranged vertically in the housing (on each side). The nozzles on each side were fitted from top to bottom with 2 no. 5, 2 no. 3 and 3 no. 3 discs. The 5 nozzles used to cover the two rows under the machine were equipped with no. 3 discs. All nozzles contained 2 hole whirl plates except those with no. 5 discs where 3 hole whirl plates were used.

4. A Bean Model 15-RC Aircrop Attachment with one sided discharge manifold consisted of 12 nozzles arranged vertically in two rows within the discharge head. The nozzles were fitted from top to bottom as follows: 2 with no. 7 discs and no whirl plates, 5 with no. 2½ discs and no whirl plates, 1 with no. 5 disc and 2 hole whirl plate, 1 with no. 2½ disc and 2 hole whirl plate, 3 with no. 5 discs and 2 hole whirl plates. A fan type nozzle with a no. 2½ disc was mounted just outside the air outlet on the bottom to spray the inside of the row next to the sprayer. Rows straddled by the sprayer were covered by a 5 nozzle hydraulic brush type boom.

All blower attachments were mounted on special trailers except the Bean 15-RC unit which was on a conventional sprayer. The units were adjusted to the same height of 30 inches above ground. The trailer mounted blower attachments were drawn behind and utilized the tank and pump of a standard 400 gallon hydraulic boom sprayer equipped with a Bean Royal 35 pump operated at 400 p.s.i. In this way, different units could be readily interchanged in the field. The power unit on all of the attachments was a VF-4D Wisconsin air-cooled engine. A hydraulic sprayer equipped with a brush type boom was used as a basis of comparison in this work.

## Rates, Spray Schedules, Plot Sizes

The air-blast attachments were calibrated to deliver 50-55 gallons of 2x Bordeaux mixture (16-8-100) per acre depending on the nozzle arrangement and the size of the plot to be covered except the Bean 15-RC which delivered 75 gallons of 1½x Bordeaux mixture (12-6-100) per acre. The hydraulic sprayer delivered 100-110 gallons of Bordeaux mixture (8-4-100) per acre.

The plots were sprayed on a regular schedule throughout the season. The treatments were replicated 2 or 3 times depending on space available. Length of plots varied from 250 to 500 feet during the different years.

Plots were sampled twice in 1953, one when plants were 8 in. tall and later at full bloom. All other samples (1954-1955) were taken when

the plants were at the full bloom stage. With but two exceptions, in which the Cobbler and Katahdin were used, all tests were conducted on the Green Mountain variety.

Plots varied from 22 to 30 rows for the air-blast machines and 8 rows for the hydraulic boom machine. Two plot sizes were used in 1953 to determine the effective swath covered by the machines tested. One sided discharge machines were driven so as to spray toward the center of each plot from 2 sides resulting in a double swath plot. The 2 sided discharge machines were driven through the center of the plot spraying in both directions and then driven around the periphery of the plot spraying toward the center. This resulted in a plot consisting of 2 double swaths.

Following a preliminary series of experiments in which a close correlation was obtained between separate deposits of DDT and copper, Bordeaux mixture was used for deposit studies because of the ease in analysis. In order to obtain information on the quantitative distribution of the sprays, leaf samples were collected from plants in designated rows in the plots. Leaflets were removed from the top, middle and bottom position of plants in 150 feet of row. In taking samples, leaflets were collected (50 per sample position per row) and bagged in the field. These were taken immediately to a shelter where they were stacked in groups to save punching time and punched with a 1.65 cm. diameter cork borer (1 disc per leaflet). The leaf discs were taken to the laboratory where they were analyzed for copper deposit using a modification of French's method (3).

Collected samples (fifty 1.65 cm. discs) were placed in 250 ml. beakers and 150 ml. of 0.2 per cent $HNO_3$ added. They were allowed to stand over night letting the copper dissolve from the leaf surfaces. The dilute acid was poured off and a 5 ml. aliquot of the solution from each sample was withdrawn and placed in a 150 ml. Erlenmeyer flask. One ml. of concentrated $NH_4OH$ and 0.5 ml. of a 20 per cent aqueous solution of sodium diethyldithiocarbamate was added. When the flask was shaken, the copper appeared as a brownish precipitate. Exactly 15 ml. of pure isoamyl alcohol were added and the contents of the flask were shaken on a mechanical shaker for 5-7 minutes to allow the copper precipitate to be completely extracted by the solvent. The entire contents were poured into a 50 ml. centrifuge tube and centrifuged at 1200 RPM for about 5 minutes. The water layer at the bottom of the tube was removed with a small drawn-out glass tube attached with soft rubber hose to a suction line. By pinching the rubber hose, the glass tube could be inserted without removing any of the alcohol. The water was caught in a catch bottle in the suction line. Colorimetric determinations of copper in the samples were made on a lumetron colorimeter using a green filter. The per cent transmission was recorded and related to a standard curve which had previously been established. Since the total volume of the solutions was measured, it was possible to calculate the amount of copper present on the leaf discs as micrograms per square centimeter, no distinction being made between upper and lower surfaces.

Leaf prints, prepared according to the techniques described by Blodgett and Mader (1), were made in 1953 in order to obtain qualitative deposit information between upper and lower leaf surfaces. Prints were made from

samples collected from some of the positions on the plants previously indicated.

Wind velocities were determined during all spray operations using a Keuffel and Esser Co. anemometer.

No late blight was present in the area during the course of the experiments.

## Results

The highest copper deposits were found in the center of a 22 row plot (Figure 1 top line) when 8 in. plants were sprayed for the first time with a one sided discharge machine. These deposits were higher than those put down by the standard hydraulic boom sprayer. However, when a 26 row plot (Figure 3, top line) was used, a lower deposit in the center of the plot indicated that an area too wide to be covered by the two spray swaths from the machine was being used. Comparable results were found with the Hurst Aqua-Jet two sided discharge machine (Figure 2).

Deposit data taken after the third spraying at the full bloom stage (maximum height) were markedly different as shown in figures 1, 2, and 3 in the same plots. The pattern with the one sided discharge unit in this case shows a lower copper content on leaves in the center of the plot. It was found in later experiments (Table 1) that total copper deposits on plants in the center rows, in a 22 row plot, were significantly lower when sprayed with the regular nozzle arrangement of the air-blast attachment when applied with the standard boom. The low deposits on row 10 (Figure 2) with the two sided machine indicates that a small amount of spray material was being carried under the machine. Row 17 (Figure 2) appears to indicate a drop in the effective swath from both directions.

## Near Side *vs.* Far Side of Row in Relation to Air Blast

Samples taken from each side of the sample row at the top and bottom of the plants show that the side of the row toward the machine consistently received a higher copper deposit than did the far side of the same row. In figures 4 and 5 the near and far side effects are evident as the right and left sides with a one sided machine. Figures 6 and 7 indicate similar results with a two sided machine. The point where the plants received the same amount of material on each side indicates where the swaths overlap. An average of the samples taken from the top, middle and bottom positions from each side of the sample row indicates a significant difference between the side of the row close to the machine and the side away from the machine (Tables 2 and 3). However, these differences appear only in rows near the machine and were not significant in the center or where spray swaths overlap each other.

## Copper Spray Deposits in Top Portions *vs.* Bottom Portions of Plants

In all cases, the top portions of the plants received a greater amount of spray material than the bottom portions. This was evident when the average curve in Figure 4 was compared with Figure 5, and Figure 6 with

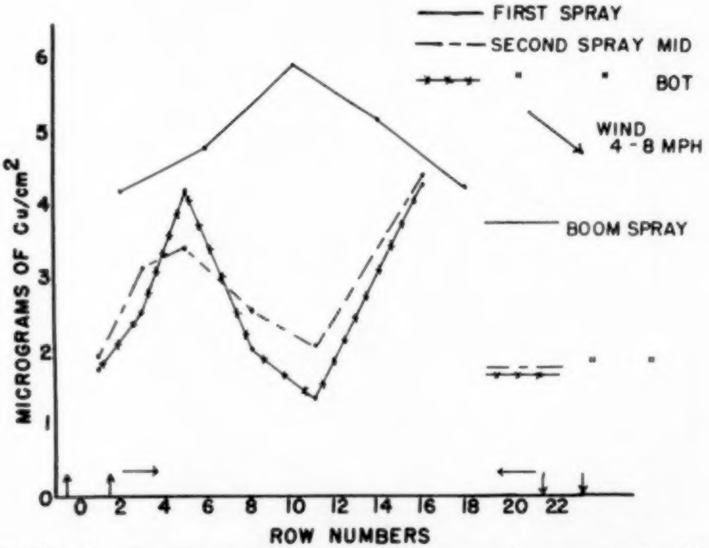


FIGURE 1.—Average copper deposits on plants in a 22 row plot sprayed with a Myers unit. First spraying and third spraying with samples from middle and bottom portions of plants compared with boom sprayed rows on Green Mountain variety.[1]

[1]Vertical arrows indicate wheel tracks and direction of travel. Horizontal arrows indicate direction of air blast.


FIGURE 2.—Average copper deposits on plants in a 22 row plot sprayed with the Hurst Aqua-Jet. First spraying and third spraying with samples from middle and bottom portion of plants compared with boom sprayed plants on Green Mountain variety.

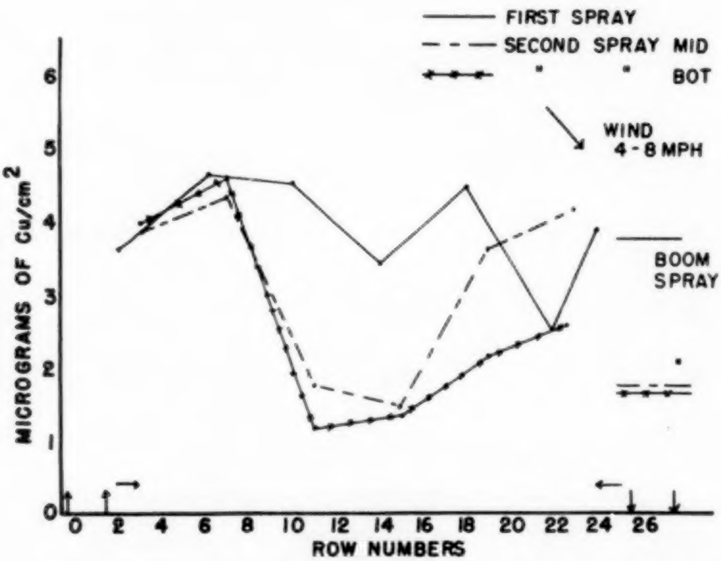


FIGURE 3.—Average copper deposits on plants in a 26 row plot sprayed with the Myers unit. First spraying and third spraying with samples from middle and bottom portions of plants compared with boom sprayed plants on Green Mountain variety.

TABLE 1.—*Row averages of copper deposits with one sided Myers Unit using regular nozzle arrangement.*[1]

| Row | ugm Cu/cm² | Row | ugm Cu/cm² |
|---|---|---|---|
| 2 | 5.90 | 11 | 3.05** |
| 4 | 5.20 | 13 | 3.20** |
| 6 | 4.80 | 15 | 3.70 |
| 8 | 3.55** | 17 | 4.90 |
| 10 | 3.05** | 19 | 5.65 |
| Boom-sprayed rows | | | 4.65 |
| | | L.S.D. 5 per cent | .76 |
| | | 1 per cent | 1.04 |

[1]Samples from six positions per row in a 22 row plot. No. 5 discs after 4th spraying on G. Mountain variety.

**Significantly lower than boom sprayed rows at odds 99 to 1.

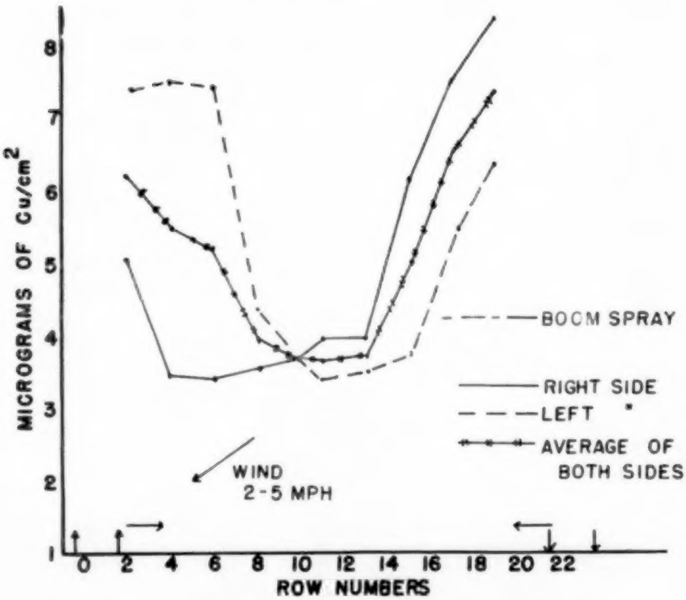


FIGURE 4.—Copper deposits for the top right and left side of plants in sampled rows and the average of both sides sprayed with the Myers unit, 22 row plot, No. 5 discs, compared with boom sprayed plants on Green Mountain variety.

Figure 7. For the most part the deposit on the top samples in rows located in the center of a 22 row plot (Figures 4 & 5) sprayed with the one sided Myers machine using no. 5 discs were lower than those sprayed with a boom sprayer. Practically all the bottom deposit samples were lower than those sprayed with the boom sprayer. It is interesting to note that the bottom samples with a boom sprayer were slightly higher than the top samples. When statistically analyzed, composite samples from rows 8, 10, 11, 13 were significantly lower in total copper deposits than from the boom-sprayed rows (Table 1).

Somewhat similar patterns were found with the two sided (Bean 12-RC) machine, however, it should be noted that the number of rows covered by each swath was less than for the one sided machine (Myers). consequently there was a build up where spray swaths overlap in the top samples (Figure 6). Almost all these samples had a higher deposit than did the standard boom-sprayed samples. The bottom samples from plots sprayed with the Bean 12-RC received considerably lower deposits as shown in Figure 7. However, samples from rows 3 and 15, close to the machine, had higher deposits than the top samples.

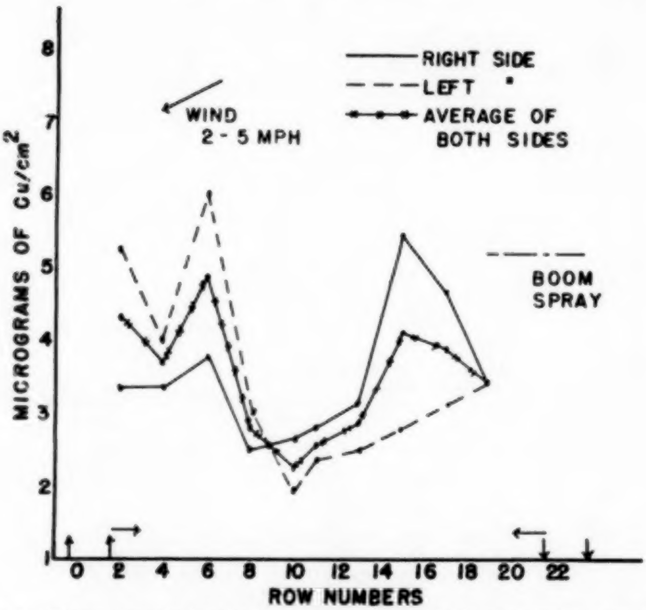


FIGURE 5.—Copper deposits for the bottom right and left side of plants in sampled rows and average of both sides sprayed with Myers unit, 22 row plot, No. 5 discs, compared with boom sprayed rows on Green Mountain variety.

TABLE 2.—*Row side averages of copper deposits with one sided Myers Unit using regular nozzle arrangement.*[1]

| Row | Loc | ugm Cu/cm² | Row | Loc | ugm Cu/cm² |
|---|---|---|---|---|---|
| 2 | F[2] | 4.45) | 11 | N | 3.37 |
| | N | 7.28)** | | F | 2.87 |
| 4 | F | 3.67) | 14 | N | 3.53 |
| | N | 6.72)** | | F | 2.83 |
| 6 | F | 3.72) | 15 | N | 4.50)** |
| | N | 5.90)** | | F | 2.90) |
| 8 | F | 3.33 | 17 | N | 5.88)** |
| | N | 3.92 | | F | 3.88) |
| 10 | F | 3.22 | 19 | N | 6.57)** |
| | N | 2.90 | | F | 4.75) |
| | | | | L.S.D. 5 per cent | .71 |
| | | | | 1 per cent | .97 |

[1]Samples from 3 positions per row side in a 22 row plot. No. 5 discs after 4th spraying on G. Mountain variety.

[2]N = side of row toward air blast, F = side of row away from air blast.

**Significantly higher at odds 99 to 1 when comparing N with F.

TABLE 3.—*Row side averages of copper deposit with two sided Bean 12-RC Unit.*[1]

| Row | Loc | ugm Cu/cm² | Row | Loc | ugm Cu/cm² |
|---|---|---|---|---|---|
| 3 | F[2] | 4.71) | 15 | F | 4.50) |
| | N | 7.15)** | | N | 7.88)** |
| 5 | F | 5.86 | 18 | F | 4.95) |
| | N | 6.63 | | N | 6.67)* |
| 7 | F | 5.95 | 20 | F | 4.73 |
| | N | 6.38 | | N | 5.55 |
| 8 | N | 5.88 | 21 | N | 5.05 |
| | F | 5.85 | | F | 5.10 |
| 10 | N | 5.47)* | 23 | N | 6.26)** |
| | F | 3.93) | | F | 4.23) |
| 12 | N | 5.95)* | 26 | N | 7.32)** |
| | F | 4.30 | | F | 5.23) |
| | | | | L.S.D. 5 per cent | 1.28 |
| | | | | 1 per cent | 1.74 |

[1]Samples from 3 positions per row side in a 28 row plot. After 4th spraying on G. Mountain variety.

[2]N = side of row toward air blast, F = side of row away from air blast.

*Significantly higher at odds 19 to 1 when comparing N with F.

**Significantly higher at odds 99 to 1 when comparing N with F.

## NOZZLE ARRANGEMENTS

Modifying the nozzle arrangement on the Myers machine resulted in a different overall deposit curve across the spray plot. Figure 8 shows the amount of material deposited after one spraying of Bordeaux mixture on the sampled rows at the top and bottom locations on the plants with no distinction being made between left and right side of the row. More material was carried to the center of the plot with the modified nozzle arrangement than with the regular nozzle arrangement when compared with the hydraulic boom sprayed plants. This was probably due to the larger droplets being discharged from the larger discs. Using the regular nozzle arrangement resulted in a very fine mist that was easily blown about by cross winds. However, deposits still remained low on the bottom portions of the plants.

## EFFECT OF WIND

Wind velocities over 10 mph seriously impeded the performance of the machines. Under such conditions the mist stream was blown back at the machine thus limiting the effective swath to only a few rows or was carried a longer distance with the wind. Figure 8 shows a slight shift in the deposit pattern due to a 5-9 mph wind. As the spray material was discharged from the manifold, winds tend to buffer it down or upward.

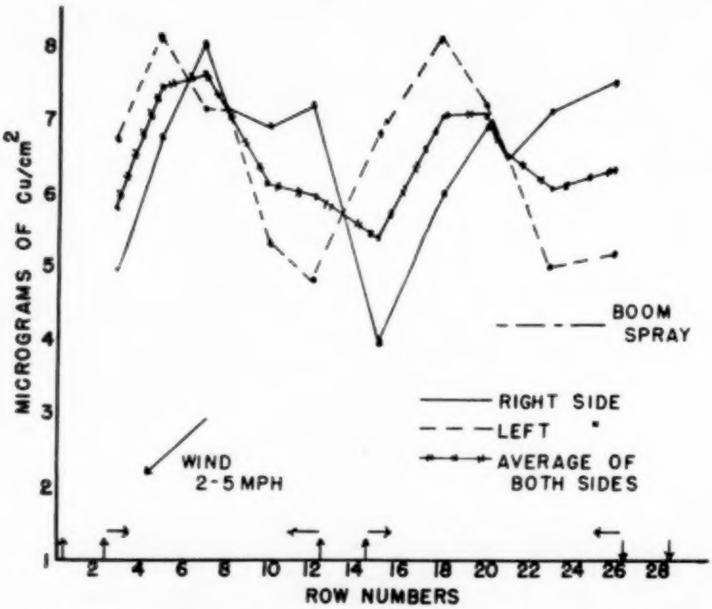


FIGURE 6.—Copper deposits for the top right and left side of plants in sampled rows and average of both sides sprayed with a Bean 12-RC unit, 28 row plot, compared with boom sprayed rows on Green Mountain variety.

## SWATH WIDTH COVERED BY MACHINES

The number of rows that could be covered by a particular machine depended largely on manifold design in relation to one or two sided discharge and nozzle arrangements. The use of larger discs at the top of the manifold resulted in a larger discharge, presumably with larger droplets, that could be carried further away from the machine by a combination of their inertia and the air stream. This is evident in Figures 8 and 9. In most cases, 6 to 7 rows (18-21 feet) were covered on each side by a two-sided discharge machine and 10 to 13 rows (30-39 feet) with a one-sided machine when used with the proper nozzle arrangements.

## DISTRIBUTION OF COPPER ON LEAF SURFACES

Leaf print data in 1953 showed that when plants were small (8 in. high), upper leaf surfaces were covered with a higher spray deposit in most cases when sprayed with an air-blast sprayer than when sprayed with the hydraulic boom sprayer. Lower leaf surfaces showed less spray material than the upper leaf surface except for rows close to the machines where lower leaf surfaces were exposed to the spray blast. When the spray swaths overlapped in a 22 row plot, uniform distribution was found on the upper

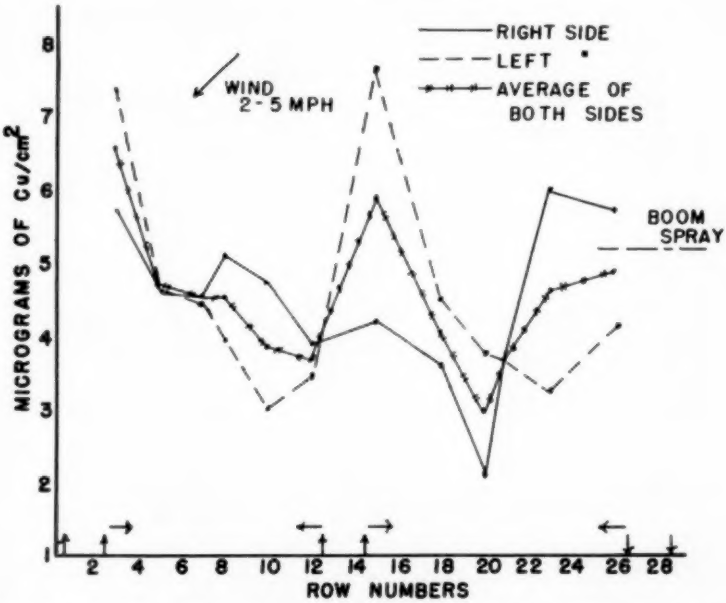


FIGURE 7.—Copper deposits for the bottom right and left side of plants in sampled rows and average of both sides sprayed with a Bean 12-RC unit, 28 row plot, compared with boom sprayed rows on Greenn Mountain variety .

and lower leaf surfaces on either side of the row. Plants sprayed with the hydraulic boom sprayer showed slightly lower spray deposits on the lower leaf surfaces when compared with upper leaf surfaces.

Leaf prints taken, after the third spraying, from the bottom of plants at their maximum height showed that both upper and lower leaf surfaces contained only a light deposit of spray material except in those rows close to the machine. Plants in the smaller plots (22 row) showed slightly heavier deposits than plants in the wide plots (26 row). Plants sprayed with a boom sprayer showed more deposit on the upper leaf surfaces than on the lower leaf surfaces.

Leaf prints taken from the middle position on the plants again showed more uniform distribution on the upper surfaces on rows in the center of the plots than on rows close to the machine. It appears that the material was sprayed on to the plants near the machine but that droplets fell by gravity on plants away from the machine.

## Discussion and Summary

Several factors must be taken into consideration when air-blast type spray equipment is to be used on potatoes. In a series of experiments conducted with four air-blast attachments information was found, based on

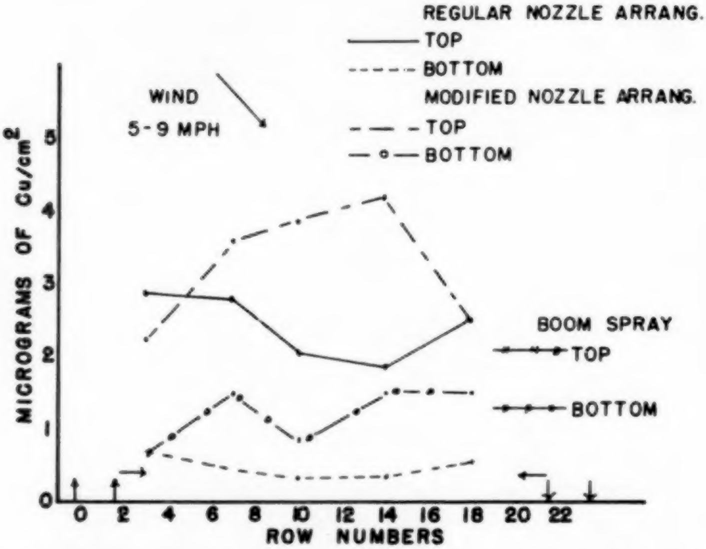


FIGURE 8.—Average copper deposits for the top and bottom portions of plants in rows sprayed with a Myers unit, using a regular and modified nozzle arrangement compared with boom sprayed rows. Samples taken from a 22 row plot of Katahdins after one spraying of Bordeaux mixture.

copper deposit data, concerning the effectiveness of these machines.

Considerably better coverage was obtained when 8 in. plants were sprayed than when plants were sprayed at their maximum height. This was apparent in both 22 and 26 row plots. However, modification of the nozzle arrangement helped to correct the small amount deposited in the center of the plot based on total copper samples.

In general, the side of the row toward the mist blower consistently received more spray material than the side away from the blower. The rows in the center of the spray plot or the area where the spray swaths overlapped received more or less uniform spray deposits on both sides.

When plants were small, there was a tendency to deposit more material in the center of the plot. This increased deposit reflects the overlapping effect when the spray swaths extend beyond the center of the plot. However, maintaining the same plot width throughout the spray season may result in less material deposited in the middle of the plot when plants are larger.

In all cases, the upper portion of the plants consistently received a greater amount of spray material than the bottom portion. Deposits on the upper portions were considerably higher than from the standard boom application while deposits on the bottom portions were much lower. In such cases the possibility exists that the heavy deposits at the maximum peaks might lead to residue or phytotoxicity problems while the lighter

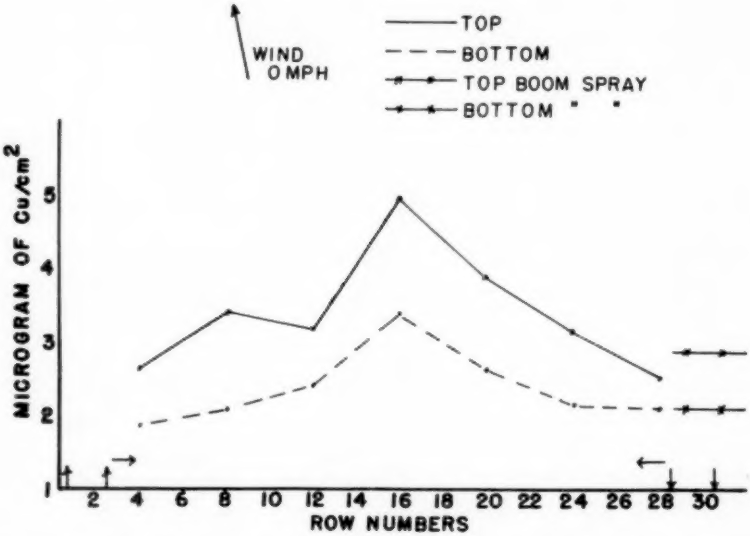


FIGURE 9.—Average copper deposits for top and bottom portion of plants in rows sprayed with Bean 15-RC unit compared with boom sprayed rows. Samples taken from a 28 row plot of Cobblers after one spraying of Bordeaux mixture.

deposits might be ineffective against heavy insect or serious disease problems.

Adjustments in nozzle arrangement were necessary to obtain better coverage and to increase effective swath width. However, the fact still remains, that the bottom portion of the plants received less spray material.

Although the plots were sprayed when wind conditions were at the lowest velocity, some effects were visible in the deposit data. In general, winds up to 5-6 mph did not seriously impede the performance of the machines. However, machines equipped with nozzles discharging a fine droplet size were affected more than ones producing larger droplet size. It was noted in many cases that the wind was able to alter the effective air-blast so coverage was obtained only on 2 or 3 rows away from the machine. However, the mist stream was able to blow over 20 to 25 rows when the wind was in its favor. Apparently such droplets dry out and become too small to impinge on the leaves and consequently low deposits were found in such areas.

The number of rows that can be covered by any particular machine depends largely on manifold design, one or two sided discharge, nozzle arrangement, size of plants and direction and velocity of prevailing winds.

Distribution of copper deposits on the top leaf surfaces were greater than those on the lower leaf surfaces. However, in rows where the air stream could effectively move the foliage, the lower leaf surfaces on the

side of the row toward the blower received more material than the upper surface while the opposite was found on the side of the row away from the blower.

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# SCHULTZ POTATO VIRUS COLLECTION[1]

R. E. WEBB[2]

The most complete collection of potato viruses in the United States is maintained on Aroostook Farm, Presque Isle, Maine, and at Beltsville, Maryland. The collection contains 15 distinct viruses, some of which occur as strains, that cause certain diseases of the potato (Table 1). Most of the viruses were originally obtained by natural selections and later intensively studied by E. S. Schultz, United States Department of Agriculture, in collaboration with Donald Folsom, Maine Agricultural Experiment Station. A few of the viruses were submitted for study by other investigators and then entered in the collection as stock cultures.

This collection has become virtually the type culture collection of potato viruses for the United States. Certainly no other group of potato viruses in this country has been maintained, tested, and selected for type symptoms induced in the host while under the continuous personal supervision of one of its founders for almost 40 years. Most potato pathologists in the United States and some in foreign countries at one time or another have obtained virus cultures from the collection.[3] Some potato-disease investigators who are unable to maintain virus cultures in their laboratories request them regularly each year. In 1956 alone, cultures of 18 strains of 8 viruses were requested by pathologists in 8 States and 1 foreign country.

Dr. Schultz is co-founder of the collection and maintained the cultures alone from 1936[4] until his retirement in 1954. It may therefore be considered as largely his personal collection of potato viruses. In recognition of the tireless efforts of Dr. Schultz in preserving this valuable collection and his invaluable services to the industry, the collection has been named the Schultz Potato Virus Collection.

*Description of the Collection.* The name of each virus or strain in the collection, date of its selection or receipt, potato variety from which each was selected, date entered in the collection and the publication in which appeared the original description of the disease incited are listed in table 1. Most of the viruses and strains were isolated from naturally occurring diseased specimens in Maine. Cultures of viruses identified in other areas were supplied by the following contributors: Witches'-broom virus by B. F. Dana, Pullman, Washington; calico mosaic virus by T. P. Dykstra, Corvallis, Oregon; yellow dwarf virus by F. M. Blodgett, Ithaca, New York.

The virus collection actually dates from 1916. Dr. Schultz and Dr. Folsom were then collaborating on a study of the causes and control of the degeneration diseases affecting potatoes in Maine. That year they recognized in the variety Green Mountain, the first distinct degenerative disease, mild mosaic. In the next decade, these 2 workers selected and studied 10

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[1]In cooperation with Maine Agricultural Experiment Station.
[2]Senior Pathologist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, Beltsville, Md.
[3]Requests are submitted to Chief, Plant Quarantine Branch, for approval prior to shipment of infected material.
[4]Dr. Reiner Bonde, Maine Agricultural Experiment Station, assisted Dr. Schultz in maintaining the virus cultures from 1924-1935.

different virus diseases of the potato in Maine and worked out the basic principles for their control (7,8). During this period it was first realized that insects were important carriers of viruses and the virus cultures therefore were placed under insect-proof cages to prevent contamination and insure against loss of the original virus and plant specimen.

*Maintenance.* Each virus culture has been maintained in tuber progeny, and plants of the original variety in which it was first selected. Subinoculation from the original cultures to other potato varieties and seedlings were necessary for study and identification. Two seedlings, one designated S 41956 (immune from virus X) and another of Green Mountain (virus X-free) closely resembling the commercial variety Green Mountain, proved adaptable for the maintenance of the viruses free of virus X. Since virus S has been reported, some of the viruses have been transferred to the variety Saco, which is immune from viruses A, S, and X.

Each potato variety or seedling containing a virus culture is grown under 2 separate insect-proof cages in the field (Figure 1). Four plants are grown in each cage. This usually supplies sufficient tubers of each variety for study, for replanting the cages and for distribution to other investigators.

Prior to 1955, propagation of the virus culture was done under cages enclosed with fine-mesh copper wire and heavy muslin (right rear, Figure 1). It was found that only a few varieties and seedlings would tuberize under these cages, and furthermore during cool, moist, cloudy seasons some cultures were in serious danger of being lost. Twelve cages were modified in 1955 to provide a 12-inch pliofilm (acetate, .10 weight) strip

FIGURE 1.—Virus culture maintenance plot on Aroostook Farm, Presque Isle, Maine. Cultures have been maintained under these insect-proof cages since 1922 to prevent contamination, and insure against loss of the original virus and plant specimen.

TABLE 1.—*Potato viruses and strains in the Schultz Collection.*

| Virus or Strain | Original Host Variety | Year Selected or Received | Year Placed in Insect-proof Cages | Citation for Original Description of Disease Caused by Virus or Strain |
|---|---|---|---|---|
| Apical leaf roll | Katahdin | 1925 | 1928 | Schultz and Bonde (9) |
| Aucuba mosaic | Green Mountain | 1925 | 1925 | Quanjer (6) |
| Calico mosaic | Green Mountain | 1929 | 1930 | Porter (5) |
| Interveinal mosaic | Green Mountain | 1923 | 1924 | Schultz (10) |
| Latent mosaic (virus X);[1] | | | | Smith (11) |
| weak strain | Green Mountain | 1931 | 1932 | |
| faint strain | Green Mountain | 1931 | 1932 | |
| medium strain | Green Mountain | 1936 | 1936 | |
| severe strain | Green Mountain | 1934 | 1935 | |
| virulent strain | Early Rose | 1933 | 1934 | |
| Leaf roll; | | | | |
| mild (1) strain | Green Mountain | 1921 | 1930 | Schultz and Folsom (7) |
| moderate (2) strain | Green Mountain | 1951 | 1955 | Webb, Larson and Walker (12) |
| severe (3) strain | Green Mountain | 1951 | 1955 | |
| Leaf rolling mosaic | Green Mountain | 1922 | 1931 | |
| Potato virus A; | | | | Schultz and Folsom (7) |
| mild strain | Green Mountain | 1916 | 1922 | Schultz and Folsom (7) |
| crinkle strain | Green Mountain | 1922 | 1922 | |
| Potato virus S | S 41956 | 1956 | 1956 | DeBruyn Ouboter (3) |
| Spindle tuber | Green Mountain | 1921 | 1929 | Schultz and Folsom (7) |
| Unmottled curly dwarf | Green Mountain | 1921 | 1922 | Schultz and Folsom (7) |
| Potato virus Y; | | | | Schultz and Folsom (7) |
| common strain | Green Mountain | 1921 | 1922 | |
| stipple streak strain | Green Mountain | 1921 | 1925 | |
| Witches'-Broom | Cobbler | 1923 | 1924 | Hungerford and Dana (4) |
| Yellow dwarf | Russet Burbank | 1935 | 1935 | Barrus and Chupp (1) |
| Yellow spot | Katahdin | 1955 | 1955 | Bonde and Merriam (2) |

[1]Strains identified by E. S. Shultz by inoculation to *Datura stramonium* L.

around the upper half of the cage for better illumination of plants. An 8-inch strip of fine-mesh copper wire just below the pliofilm and one on each side of the top provided ventilation. Heavy muslin with an 18-inch closely meshed zipper sewn in the middle was used to cover the top center portion of the cage. This facilitated close inspection of the enclosed plants and allowed for periodic application of an insecticide and fungicide. Figure 2 shows the increased yields of tubers produced by healthy Katahdin plants under the newer type cage.

The collection is observed closely during the growing season and when the cages are removed at harvest time, each plant is closely inspected for insects, particularly aphids. The vines are removed, and the tubers from each plant in each cage are harvested separately and divided into 2 lots, one for replanting the same hill in the cage the following year and the other for distribution to investigators and for greenhouse tests at Beltsville, Maryland.

One tuber from each hill in the collection is planted in the greenhouse at Beltsville for observation of plant symptoms and tests for purity of the virus culture. Variations in plant type or virus symptom characteristics are noted. Tubers from the affected plants are removed in order to maintain the original type virus. Similar observations are conducted in a small observational plot planted at Presque Isle, Maine.

Maintenance of the present stock culture collection of potato viruses requires approximately 100 insect-proof cages. These are all of the newer type which permits better illumination of the growing plants. About 10 to 15 medium-sized tubers are usually obtained from each cage, and experience has shown that these are sufficient to insure maintenance of each culture and furnish infected material for disease investigations.

*Value of the Collection.* This virus collection has been and still is of immeasurable value to potato disease investigators and the potato industry. Type cultures secured from the collection have been used in basic research on potato viruses such as physical properties, strain variations, serological studies, virus-vector relationships, genetic studies and studies of the nature of host resistance. Pure cultures of viruses maintained in the collection have played an important part in the development of disease control through use of insecticides and the development of disease-resistant varieties. Most potato varieties resistant to virus diseases that have been released jointly by the United States Department of Agriculture and cooperating States since 1930 were initially evaluated by inoculation with virus cultures from this collection.

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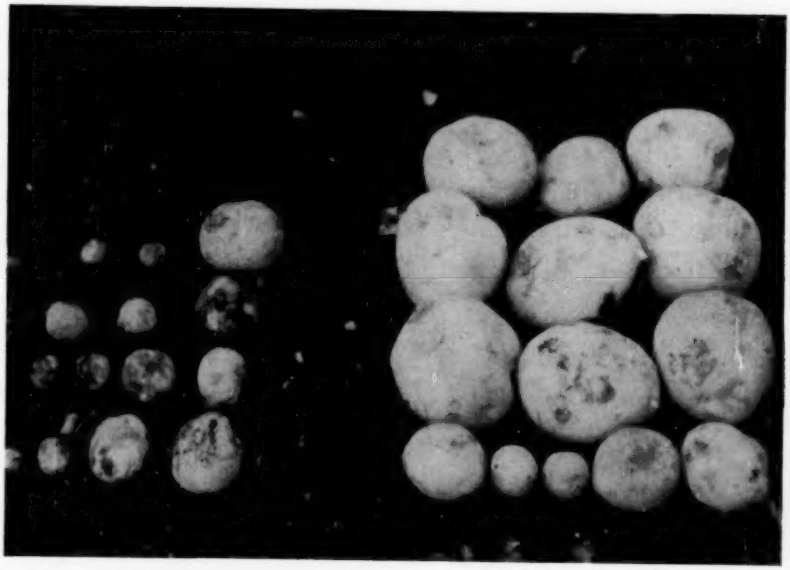

FIGURE 2.—Yield of tubers produced by healthy Katahdin plants grown under insect-proof cages. Left, wire-covered; right, pliofilm- and wire-covered.


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# TIMING MALEIC HYDRAZIDE SPRAYS TO STAGE OF PLANT DEVELOPMENT[1]

R. L. SAWYER AND S. L. DALLYN[2]

Maleic hydrazide had given inconsistent sprout control on Long Island when used according to the recommendations of northern growing areas. The northern recommendations are usually based on a certain number of days before harvest or before the vines start to go down. This paper deals with an attempt to tie time of application to a definite stage in plant development.

The importance of time of application was demonstrated by Kennedy and Smith (4). Sprays applied early in the season caused increased tuber set and yield reduction. Applying the material before vines were in an advanced stage of maturity so that the material would be translocated was of major importance in obtaining sprout control. Wittwer and Paterson, (6) Highlands, Licciardello and Cunningham (3) Franklin and Thompson (2) all found that satisfactory sprout control could be obtained from maleic hydrazide sprays applied several weeks before harvest. Denison (1) found that a blossom fall application of maleic hydrazide gave less detrimental effects to the tubers than earlier sprays. Salunke and Wittwer (5) obtained beneficial effects on specific gravity and color of potato chips from the use of maleic hydrazide but, in general, other workers have not noticed these effects.

## MATERIALS AND METHODS

Maleic hydrazide at 3 and 5 pounds per acre was applied to Katahdin tubers at five dates of application in 1953. These dates were early bloom, full bloom, blossom fall and two and four weeks from blossom fall. Sprays were applied to Cobblers at full bloom, blossom fall and two weeks from blossom fall. Dates of application for 1954 were similar to 1953. To determine if the sprays would react similarly for various planting dates, dosages of 3 and 5 pounds per acre were applied to Katahdins planted April 5 and May 15. In 1955 the treatments remained similar to 1954 with planting dates of April 12 and May 8.

Plot sizes in 1953 and 1954 were 2 rows wide and 25 feet long. In 1955 plots were 4 rows wide and 27 feet long. The statistical design was set up factorially as a randomized block.

Samples were saved from each plot at harvest for the various storage determinations reported and held at 50°F. Shrinkage, sprouting and black spot data were taken in early February after 5 months storage.

Black spot index was obtained by bruising twenty pound tuber samples and peeling after 48 hours. The black spot index was from 0 through 9 taking into consideration both the severity of the black spot and the per cent tubers showing the blackening. The peeled darkening index was obtained by abrasively peeling tubers and determining the amount of discoloration that had taken place in one hour. One indicated no discoloration and nine severe discoloration. The chipping index was

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obtained by frying cured samples and rating the color of the chips 1 through 9. One indicated very dark chips and 9 light chips with 5 considered the darkest level for commercial acceptability. Chipping samples for 1954 were held at 40°F and for 1955 at 50°F. Tuber analysis for maleic hydrazide was made by Naugatuck Chemical.

## Results and Discussion

Maleic hydrazide gave excellent sprout control for the 1953 season when applied at blossom fall and shortly thereafter. When applied later than two weeks from blossom fall, even though vines were still green and growing, a dosage of 5 pounds per acre was necessary for sprout control with Katahdin tubers. There were no effects on quality or yield at any date of application. Residue analyses corresponded very well with sprouting. Results for the 1953 season are shown in table 1.

In 1954 the dosage and date of application of maleic hydrazide had no effect on yield. This was interesting to note since this was the second season in a row that early bloom applications did not give the yield reductions other workers have reported. Specific gravity of maleic hydrazide-treated tubers tended to be lower than checks. Sprays applied later than two weeks from blossom fall failed to give good sprout control although vines were still green. Sprays reacted similarly on potatoes from both dates of planting although there was considerably less sprouting with the late planted tubers. Maleic hydrazide sprays had no effect on black spot or peeling discolorations. There was a tendency for tubers treated with five pounds of maleic hydrazide per acre to chip lighter. Tubers had been stored at 40°F before curing and all samples chipped relatively dark. Results for 1954 are given in table 2.

In 1955 applications of maleic hydrazide gave a decreased yield at early bloom with both early and late planted tubers. With early planted tubers a full bloom application caused a decrease in yield. Maleic hydrazide sprays had no effect on black spot, peeled discoloration or specific gravity of tubers. Sprays at the blossom fall stage and full bloom stage gave excellent sprout control. The spray dates which gave the most effective control of sprouting also had a tendency to give poorer chipping color. Results for 1955 are given in table 3.

Effective sprout control with maleic hydrazide sprays was obtained by proper timing. Planting dates and harvest dates vary so in areas such as Long Island that timing cannot be made according to number of days before harvest even though vines may be green several weeks after application. Sprays applied earlier than blossom fall gave yield reductions some years. Sprays applied later than blossom fall tended to give reduced sprout control even though vines were an actively growing green at application. The blossom fall application date gave good results each year regardless of the date at which potatoes were planted. In general, maleic hydrazide had no consistent detrimental effect on the various darkening reactions tested which are associated with the potato tuber.

Several noteworthy indications not directly concerned with maleic hydrazide were obtained from these factorial experiments. The late date of planting tended to give a reduced sprouting problem in storage. This was probably due to the greater immaturity of the late planted tubers and the

TABLE 1.—*Effect of Maleic hydrazide sprays on two potato varieties for sprout control in 1953.*

| Variety | Dosage | Application Time | Yield U.S. No. 1/A | Specific Gravity | Grams Sprouts per Kilogram Tuber | Residue P.P.M-MH-40 |
|---|---|---|---|---|---|---|
| Cobbler | 3 | Full bloom | 503 | 1.0761 | 32 | 3.4 |
| " | 5 | Full bloom | 486 | 1.0805 | 12 | 8.7 |
| " | 3 | Blossom fall | 539 | 1.0781 | 15 | 6.1 |
| " | 5 | Blossom fall | 484 | 1.0771 | 7 | 20.5 |
| " | 3 | 2 wks. from blossom fall | 543 | 1.0797 | 45 | 11.7 |
| " | 5 | 2 wks. from blossom fall | 477 | 1.0783 | 39 | 11.5 |
| | Check | | 445 | 1.0787 | 91 | Check |
| Katahdin | 3 | Early bloom | 660 | 1.0735 | 11 | 7.9 |
| " | 5 | Early bloom | 655 | 1.0717 | 17 | 5.5 |
| " | 3 | Full bloom | 582 | 1.0720 | 2 | 12.6 |
| " | 5 | Full bloom | 601 | 1.0725 | 8 | 11.8 |
| " | 3 | Blossom fall | 565 | 1.0740 | 7 | 18.2 |
| " | 5 | Blossom fall | 624 | 1.0722 | 0 | 18.7 |
| " | 3 | 2 wks. from blossom fall | 672 | 1.0745 | 7 | 13.0 |
| " | 5 | 2 wks. from blossom fall | 652 | 1.0715 | 1 | 9.9 |
| " | 3 | 4 wks. from blossom fall | 638 | 1.0727 | 29 | 4.2 |
| " | 5 | 4 wks. from blossom fall | 686 | 1.0745 | 4 | 5.9 |
| | Check | | 618 | 1.0730 | 33 | Check |

TABLE 2.—*Maleic hydrazide as a foliar spray for sprout inhibition in 1954.*

| Treatments | | U.S. No. 1 Bu/A | Specific Gravity | Grams Sprouts per Kilogram of Tuber | Per Cent Shrinkage | Black Spot Index | Peeling Discoloration | Chipping Index |
|---|---|---|---|---|---|---|---|---|
| *Planting Date* | | | | | | | | |
| Early Planting | | 575 | 1.0643 | 2.17 | 4.0 | 11.2 | 4.9 | 4.0 |
| Late Planting | | 586 | 1.0588 | 1.27 | 4.2 | 5.5 | 3.9 | 4.4 |
| *Dosage MH40* | | | | | | | | |
| 0 | | 596 | 1.0636 | 5.50 | 4.9 | 9.3 | 4.8 | 4.3 |
| 3 lbs/A | | 577 | 1.0618 | 1.32 | 3.9 | 8.7 | 4.4 | 4.0 |
| 5 lbs/A | | 580 | 1.0607 | 1.37 | 4.1 | 7.8 | 4.3 | 5.3 |
| *Spray Time* | | | | | | | | |
| Early Bloom | | 580 | 1.0609 | .66 | 3.7 | 7.3 | 4.1 | 4.0 |
| Full Bloom | | 560 | 1.0609 | .16 | 4.0 | 7.7 | 4.4 | 4.0 |
| Blossom Fall | | 573 | 1.0610 | .69 | 4.0 | 8.2 | 4.5 | 4.3 |
| 2 wks from blossom fall | | 586 | 1.0623 | 1.25 | 3.9 | 8.7 | 4.6 | 4.4 |
| 4 wks from blossom fall | | 595 | 1.0617 | 4.00 | 4.4 | 9.4 | 4.3 | 4.4 |
| Check | | 596 | 1.0636 | 5.50 | 5.0 | 9.3 | 4.8 | 4.2 |
| | | | | Mean Square | | | | |
| Source | D.F. | | | | | | | |
| Total | 87 | | | | | | | |
| Replications | 3 | 6973.06 | 110.67 | 1.90 | .46 | 230.68 | 1.7 | .3 |
| Dosage | 2 | 39.95 | 32.00 | .07 | .88 | 18.32 | .0 | 4.0 |
| Date of Planting | 1 | 97.23 | 671.00 | 17.67 | 1.01 | 729.45 | 21.0 | 1.0 |
| Spray Dates | 4 | 105.20 | 5.75 | 36.92 | .90 | 10.75 | .8 | .7 |
| Dosage x Planting Date | 2 | 45.83 | .00 | 1.32 | .35 | 24.04 | 1.0 | .. |
| Dosage x Spray Date | 8 | 372.45 | 14.75 | 1.10 | .32 | 25.93 | .8 | .5 |
| Planting Date x Spray Date | 4 | 70.24 | 4.50 | 2.53 | .17 | 20.33 | .3 | .. |
| Error | 63 | 164.89 | 9.12 | 3.20 | .39 | 39.77 | 1.9 | 1.0 |

TABLE 3.—*Maleic hydrazide as a foliar spray for sprout inhibition in 1955.*

| Treatments | | U.S. No. 1 Bu/A | Specific Gravity | Grams Sprouts per Kilogram of Tuber | Per Cent Shrinkage | Black Spot Index | Peeling Discoloration | Chipping Index | MH40 P.P.M. |
|---|---|---|---|---|---|---|---|---|---|
| *Planting Date* | | | | | | | | | |
| Early Planting | | 504 | 1.0793 | 3.83 | 4.14 | 21.39 | 6.6 | 5.9 | 15.6 |
| Late Planting | | 459 | 1.0812 | 3.76 | 3.99 | 24.21 | 6.6 | 6.3 | 20.4 |
| *Dosage MH40* | | | | | | | | | |
| 0 | | 568 | 1.0818 | 4.76 | 5.45 | 21.32 | 7.1 | 7.2 | .2 |
| 3 lbs/A | | 484 | 1.0803 | 2.20 | 3.67 | 24.13 | 6.6 | 6.1 | 15.9 |
| 5 lbs/A | | 505 | 1.0797 | 1.89 | 4.01 | 21.63 | 6.5 | 5.8 | 24.6 |
| *Spray Time* | | | | | | | | | |
| Early Bloom | | 245 | 1.0745 | 1.98 | 6.72 | 17.77 | 5.7 | | 22.0 |
| Full Bloom | | 422 | 1.0793 | .17 | 4.42 | 21.09 | 6.0 | | 27.8 |
| Blossom Fall | | 561 | 1.0803 | .33 | 3.53 | 24.12 | 6.4 | 4.7 | 30.3 |
| 2 wks from blossom fall | | 570 | 1.0799 | 1.59 | 3.60 | 23.62 | 6.9 | 6.8 | 14.6 |
| 4 wks from blossom fall | | 566 | 1.0798 | 4.84 | 4.39 | 20.91 | 6.4 | 6.5 | 7.0 |
| Check | | 568 | 1.0817 | 14.29 | 5.45 | 22.32 | 7.1 | 7.2 | .2 |
| | | | | Mean Square | | | | | |
| Source | D.F. | | | | | | | | |
| Total | 87 | | | | | | | | |
| Replications | 3 | 1346.83 | 11.67 | 10.24 | .29 | 72.91 | 1.33 | 5.6 | |
| Dosage | 1 | 446.51 | 4.00 | 1.24 | 1.42 | 74.75 | | 1.0 | |
| Date of Planting | 1 | 1952.39 | 50.00 | .08 | .32 | 111.08 | | 1.5 | |
| Spray Dates | 4 | 14185.08 | 1.00 | 63.07 | 3.61 | 47.74 | 1.50 | 15.5 | |
| Dosage x Planting Date | 1 | 7.81 | 2.00 | 10.44 | .78 | 201.72 | 3.00 | .5 | |
| Dosage x Spray Date | 4 | 952.71 | ..50 | .19 | .74 | 4.85 | 1.50 | 6.9 | |
| Planting Date x Spray Date | 4 | 2922.73 | 1.00 | .84 | .45 | 300.33 | 2.50. | .5 | |
| Error | 69 | 103.08 | 5.07 | 27.96 | 1.00 | 84.00 | 2.07 | 1.6 | |

consequent longer rest period. Late planted tubers showed much less black spot in 1954 than the early planted tubers. Although results from 1955 showed no differences due to planting dates, experiments on planting dates over several years have generally given the reduced black spot found in 1954. No consistent effect on quality was obtained from date of planting. The climatic conditions during the maturing season were probably of much more importance on the specific gravity than the actual planting time.

## Summary

Maleic hydrazide sprays, 3 pounds per acre, applied at blossom fall gave consistently good sprout control. Sprays at this stage of plant development gave good results to potatoes planted early or late in the season.

Maleic hydrazide sprays had no effect on black spot or peeling discoloration. There was no consistent detrimental effect on chipping quality.

Late date of planting tended to decrease sprouting and black spot but had no consistent effect on specific gravity.

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# THE EFFECT OF ZINC AS A CONSTITUENT OF POTATO FUNGICIDES[1]

L. C. CALLBECK[2]

Studies on the effect on late blight control and on the yield of potatoes when a zinc salt is included in the regular spray mixture, and on the effect on yield of treating seed pieces in solutions of zinc salts and of incorporating zinc compounds with the soil, were begun at the Science Service Laboratory in Charlottetown in 1949. A paper (3) was published in 1954 in which the results obtained up to and including 1953 were discussed. This first paper presented a review of the literature on the establishment of the essential nature of zinc in the nutrition of chlorophyll-containing plants and on many experiments that had been conducted in other regions to ascertain what effect, if any, the element exerted on the yield of potatoes. It will not be necessary, therefore, to preface this second paper with a literature review.

## EXPERIMENTS AND RESULTS

A. *Spray Tests*

In attempts during the first years of the investigation, to discover whether or not zinc-containing sprays tended to stimulate yield of tubers, zinc sulphate, used alone and added to copper fungicides, was sprayed at regular intervals on randomized and replicated plots of potatoes. The varieties employed were Green Mountain, Irish Cobbler, Kennebec, and Keswick. In these first years of study, an unsprayed check plot was included in every arrangement, and unsprayed rows of potatoes were used to separate the treatments and to border the experimental area. Each year, late blight disease attacked the foliage, causing partial or complete defoliation in the unsprayed controls and varying percentages of defoliation among the several treatments. Consequently, the yield results, although favorable to the zinc-containing sprays, must be considered to have been influenced by defoliation and by the measure of disease control achieved by the several spray mixtures. It was demonstrated (3), however, that zinc sulphate, when used alone, has some fungicidal value, and when incorporated with tribasic copper sulphate, copper oxychloride sulphate, and copper sulphate-lime sprays, increases the efficiency of these fungicides.

The conducting of spray tests, as briefly outlined above, was continued until 1955. In that year nine treatments were studied and these were: check; $ZnSO_4$; $5H_2O$, 2 lbs. in 80 Imperial gallons of water; $MnSO_4$; $2H_2O$, 2-80; nabam, 2 qts.-80; nabam + manganese sulphate, 2 qts. + 1 lb. —80; nabam + zinc sulphate, 2 qts. + 1 lb. —80; Tri-Basic Copper Sulphate (53 per cent Cu), 4-80; Tri-Basic-Manganese (48 per cent Cu, 3.5 per cent Mn), 4-80; Tri-Basic-Zinc (48 per cent Cu, 4 per cent Zn), 4-80. The three copper fungicides were prepared by the Tennessee Corporation.

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Plots of the Green Mountain variety were planted on June 14. Each plot was four rows wide by 50 feet long, and nine plots — one for each treatment — were planted in each of six ranges. Six applications were made, the dates being July 20, 29, August 9, 19, 26, September 2. When the first late blight lesions were found in the vicinity, all plots were doubled-sprayed with captan (which contains no metallic ion) in an endeavor to exclude the disease from the experiment, so that yields would not be affected by defoliation. This treatment was given on August 22, 25, 30 and September 7. However, some defoliation, in spite of this spray, occurred in the check plots, with a lesser amount in the plots sprayed with zinc sulphate solution and in the plots sprayed with manganese sulphate solution. The yields of the plots of these three treatments, therefore, must be considered to have been affected by the degree of defoliation suffered by the plants. Almost no late blight lesions were found in the other plots, and it may be assumed that yields were not affected by differences in amounts of defoliation. In order to prevent defoliation differences from developing, the plots were killed down by spraying them with a solution of sodium arsenite on September 14, or 91 days after planting. The yield data are presented in table 1 where it is shown that, under the conditions of the 1955 test, zinc, when added to nabam or tribasic copper sulphate, increased yield, the increase in both cases being greater than that produced by manganese.

TABLE 1.—*Effect of spray treatments on yield.*

| Treatment | Bushels per Acre of No. 1 Tubers | | | |
|---|---|---|---|---|
| | 1955 | 1956 | 1957 | Mean 1956-57 |
| Bordeaux | | 266.6 | 345.0 | 305.8 |
| Bordeaux + Mn | | 290.4 | 345.4 | 317.9 |
| Bordeaux + Zn | | 324.3 | 361.5 | 342.9 |
| Nabam | 195.9 | | | |
| Nabam + Mn | 203.5 | | | |
| Nabam + Zn | 214.5 | | | |
| Tri-Basic Copper | 194.2 | 299.2 | 359.3 | 329.2 |
| Tri-Basic Copper + Mn | 199.8 | 309.8 | 350.2 | 330.0 |
| Tri-Basic Copper + Zn | 205.0 | 311.1 | 376.7 | 343.9 |
| $MnSO_4.2H_2O$ | 152.3 | | | |
| $ZnSO_4.5H_2O$ | 191.7 | | | |
| Check | 137.3 | | | |
| S.D. 5 Per cent | 19.28 | | | |
| S.D. 1 Per cent | 25.80 | | | |

In 1956 and in 1957, no unsprayed plots, border rows, or buffer rows were planted, by which expedient it was hoped that late blight could be controlled completely, thus removing defoliation difference as a factor influencing yield. In both years the fungicides employed were similar: Bordeaux, 8-4-80; Bordeaux + zinc sulphate, 4-4-4-80[3]; Bordeaux +

[3]One-half the copper sulphate is replaced with zinc sulphate.
[4]One-half the copper sulphate is replaced with manganese sulphate.

manganese sulphate, 4-4-4-80[4], Tri-Basic Copper Sulphate, 4-80; Tri-Basic-Zinc (4 per cent Zn), 4-80; Tri-Basic-Manganese (4 per cent Mn), 4-80. The variety used was Green Mountain. Each plot was four rows wide by 50 feet long, and the treatments were replicated through five ranges in 1956 and six ranges in 1957. In both years, all plots were sprayed twice with DDT and once with a mixture of DDT and Malathion. The plots were planted on June 5 in 1956 and on June 3 in 1957, and, in both years, top killer was applied on September 13. Spray dates were as follows: July 16, 26, August 6, 15, 27 in 1956 and July 17, 26, August 6, 16, 28, September 6 in 1957. There was little blight in the region in 1956 and no lesions were found on the plants in this experiment, and in 1957, although disease conditions were severe in the province, the fungicides gave complete control. The plots were harvested two weeks after top killing, the two center rows being used for yield records. The results, expressed as No. 1 tubers, are given in table 1. The mean yields of the two years indicate that zinc encouraged yield increases whereas the effect of manganese was slight. In neither year were the differences statistically significant, although zinc-containing fungicides showed the favorable response reported by Ellis (4, 5), Berkeley *et al.* (1, 2), and Hoyman (6).

B. *Soil Treatment*

The effect on yield of soil applications of zinc compounds was studied during the same period as the foliage application experiments, and the data for 1951, 1952, and 1953 for the varieties Green Mountain and Kennebec were included in the previous paper. In these years, zinc acetate, zinc oxide, and zinc sulphate, used as fertilizers, gave yield increases, although in no year were the differences statistically significant.

The experiments were set up on land that had not been cultivated for several years, and because its last agricultural use predated the advent of modern fungicides and pesticides, it was reasonable to suppose that no areas had ever been treated with a zinc compound. It was on this farm that all the tests reported in this paper were carried out, and, by planned rotation, they were conducted through to 1956 on areas where zinc-containing materials had not been used. Only in 1957 was it necessary to return to an area used in previous tests.

Through the 1954-1957 period, the tests were conducted on a uniform plan, the only change being the replacement of zinc oxide by a zinc chelate in 1957. In this test, the variety, Green Mountain, was used. A plot was a single row of 50 feet, and each treatment was replicated six times. The salts $ZnSO_4 \cdot 7H_2O$ and $Zn(C_2H_3O_2)_2 \cdot 2H_2O$ were applied in solution to the drills before planting at the rate of one gram per foot, equivalent to 28.8 pounds per acre, and providing 6.55 and 8.58 pounds of metallic zinc per acre, respectively. The ZnO, being insoluble in water, was applied in powder form at a rate equivalent to 14.4 pounds per acre or 11.57 pounds of metallic zinc. The zinc chelate used in 1957 was Versonol Zinc Chelate (10 per cent Zn) of Dow Chemical Company. It was applied to the drills in solution at the rate recommended — 6.5 pounds per acre. Each year, the area was fertilized with regular commercial fertilizer at the rate of 1000 pounds per acre, appropriate applications of a copper oxychloride sulphate fungicide were made, DDT and Malathion were used

as required for insect control, and the plants were destroyed in the autumn with a sodium arsenite top killer.

The results are given in table 2, which also includes data for the years 1952 and 1953. Over the six-year period, zinc acetate and zinc sulphate, each applied as drill applications at the rate of 28.8 pounds per acre, resulted in mean gains of 14.1 and 13.6 bushels, respectively, of No. 1 tubers. An experiment, technically identical with that conducted at Charlottetown, was conducted by Dr. N. S. Wright at the Laboratory of Plant Pathology, Vancouver, British Columbia, in 1956, and included zinc sulphate and zinc acetate, each at 28.8 pounds per acre. In this test, the check plots produced a mean yield of 382.9 bushels of No. 1 tubers per acre, and the sulphate and acetate of zinc gave 429.6 and 412.9 bushels, the increase being 46.7 and 30.0 bushels, respectively.

TABLE 2.—*Effect of zinc soil applications on yield of Green Mountain potatoes.*

| Treatment | Pounds Actual Zn per Acre | Bushels per Acre of No. 1 Tubers | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1952 | 1953 | 1954 | 1955 | 1956 | 1957 | Mean |
| Check | | 323.7 | 285.7 | 348.8 | 190.5 | 190.3 | 389.0 | 288.0 |
| $ZnSO_4.7H_2O$ | 6.55 | 362.2 | 288.3 | 350.8 | 202.4 | 216.5 | 389.4 | 301.6 |
| $Zn(C_2H_3O_2)_2.2H_2O$ | 8.58 | 376.8 | 301.5 | 330.3 | 201.7 | 226.6 | 375.8 | 302.1 |
| $ZnO$ | 11.57 | | 310.5 | 361.7 | 191.5 | 203.7 | | .. |
| Zinc Chelate | 0.65 | | | | | | 382.4 | .. |

C. *Seed Piece Treatment*

The third phase in the study on the effect of zinc on the yield of tubers was concerned with seed treatment. Preliminary tests were conducted in the greenhouse in the winter of 1949-1950. In two separate tests (3), the rate of plant emergence was increased by soaking seed pieces for one minute in a solution of zinc sulphate before planting them. The same effect was observed in the field in 1950, but it appeared that the more rapid emergence and better growth was induced by the control of seed piece decay rather than by the nutritive value of zinc. In 1950, the planting was made at the beginning of a dry, hot period, and as a result emergence was retarded, and a number of seed pieces decayed. Fifteen days after the first shoots were observed, the plants in the check rows had reached a constant emergence of 86.3 per cent. Therefore, 13.7 per cent of the untreated seed pieces decayed and failed to produce plants. A maximum plant emergence of 97.9 per cent was shown by the seed pieces treated in a 1 pound-20 gallon zinc sulphate solution two days earlier than the checks; and the seed pieces treated in a 2-20 zinc sulphate solution reached maximum emergence of 96.8 per cent three days earlier than the checks reached their maximum emergence. No differences in emergence rates or growth rates were observed in any subsequent year except 1956 when the zinc treatments exerted a slight effect on emergence rate. The results suggest that zinc sulphate may have some value in preventing seed piece decay under certain conditions. Millikan (7) found that soil applica-

tions of zinc sulphate assisted cereal plants in withstanding the deleterious effects of certain microörganisms, but he did not determine whether this effect was caused by the zinc sulphate affecting the nutritional status of the plants or by its fungicidal action.

The studies on seed piece treatment were kept uniform through the 1952-1957 period. Cut seed was soaked for two minutes before planting, five treatments being employed: distilled water, hydrogen sulphate, zinc sulphate, hydrogen acetate, zinc acetate. The acid and salt solutions were 0.08N. The seed pieces were planted in single 50-foot rows, each treatment was replicated six times, and the variety Green Mountain was used throughout the six years of investigation. The plots were sprayed at proper intervals with copper oxychloride sulphate, DDT and Malathion were used at appropriate times to control insects, and commercial fertilizer at a constant rate of 1000 pounds per acre was incorporated with the soil. Perfect control of late blight disease was maintained, and the plants were killed in the autumn with a sodium arsenite top killer.

In each of the years from 1952 to 1956, the yield data showed that seed pieces soaked in zinc sulphate solution produced higher yields than seed pieces soaked in distilled water or in hydrogen sulphate; similarly, seed pieces treated in zinc acetate solution produced higher yields than seed pieces soaked in distilled water or in hydrogen acetate. In 1957, the zinc sulphate seed treatment showed the same effect as in previous years, but the zinc acetate treatment, although resulting in slightly higher yield than the hydrogen acetate treatment, fell somewhat below the distilled water treatment. In no year were the yield differences statistically significant, but, after analyzing the combined data for the 6-year period, significant increases were found for the zinc treatments. It is shown in table 3 that mean yields for distilled water, hydrogen sulphate, and hydrogen acetate are almost uniform, being 317.8, 316.7, and 316.0 bushels of No. 1 tubers per acre, respectively; both the zinc treatments resulted in considerably higher yields—338.1 and 331.1 bushels, respectively, for the sulphate and acetate of the metal.

In 1956, the seed piece treatment experiment was conducted not only at Charlottetown but also at Winnipeg, Manitoba, and at Vancouver, British Columbia. The data from this co-operative experiment are given in table 4 where it is shown that the yields on the prairie soil and the west coast soil were highest for the zinc treatments, and the mean yields for the 3-region test follow the same order as that of the mean yields for the 6-year test at Charlottetown.

## Summary

Four additional years' results on studies of the effect on late blight control and on yield of potatoes of including a zinc salt in the regular spray mixture, and of the effect on yield of treating seed pieces in solutions of zinc salts and of incorporating zinc compounds with the soil, are reviewed in this paper. Sufficient material from the preceding five years' study has been included for the purpose of sequence. The chief emphasis in this second paper is on the effect on yield.

Spray tests indicated that zinc sulphate, when used alone, has some fungicidal value, and when incorporated with tribasic copper sulphate, copper oxychloride sulphate, Bordeaux mixture, and nabam increases the

TABLE 3.—*Effect of seed treatments on yield of Green Mountain potatoes.*

| Treatment* | Bushels per Acre of No. 1 Tubers | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1952 | 1953 | 1954 | 1955 | 1956 | 1957 | Mean |
| Distilled $H_2O$ | 367.3 | 302.2 | 314.7 | 220.8 | 322.1 | 379.7 | 317.8 |
| $H_2SO_4$ | 378.6 | 291.1 | 312.4 | 224.4 | 308.0 | 385.9 | 316.7 |
| $ZnSO_4$ | 396.4 | 317.2 | 325.2 | 254.3 | 340.6 | 395.1 | 338.1 |
| $HC_2H_3O_2$ | 391.0 | 284.4 | 311.0** | 229.2 | 307.6 | 372.7 | 316.0 |
| $Zn(C_2H_3O_2)_2.2H_2O$ | 398.4 | 308.0 | 331.5 | 250.1 | 324.7 | 374.0 | 331.1 |
| L.S.D. at $P = 0.05$ | | | | | | | 9.7 |
| L.S.D. at $P = 0.01$ | | | | | | | 13.2 |

*Cut seed pieces soaked for two minutes; acid and salt solutions 0.08N.
**Hydrogen acetate was not used in 1954 and the missing yield value has been calculated according to the method of Goulden.

TABLE 4.—*Effect of seed treatments on yield in national trial, 1956.*

| Treatment* | Bushels per Acre of No. 1 Tubers | | | |
|---|---|---|---|---|
| | Charlottetown | Winnipeg | Vancouver | Mean |
| Distilled $H_2O$ | 322.1 | 310.7 | 382.9 | 338.6 |
| $H_2SO_4$ | 308.0 | 297.5 | 372.9 | 326.1 |
| $ZnSO_4$ | 340.6 | 323.4 | 396.3 | 353.4 |
| $HC_2H_3O_2$ | 307.6 | 308.5 | 392.9 | 336.3 |
| $Zn(C_2H_3O_2)_2.2H_2O$ | 324.7 | 315.7 | 399.6 | 346.7 |

*Cut seed soaked for two minutes; acid and salt solutions 0.08N.

efficiency of these fungicides. During the first several years of the spray tests, late blight attacked the foliage, and, although the zinc-containing sprays produced higher yields, it must be assumed that the yields were influenced by the variations in disease control among the fungicides. Late blight was eliminated as a factor influencing yields in 1956 and in 1957, and in both years zinc sulphate increased yields when it was added in a copper spray.

In a 6-year period of investigation, drill applications of zinc sulphate and of zinc acetate, each at 28.8 pounds per acre, gave mean increases of 13.6 and 14.1 bushels of No. 1 Green Mountain tubers; zinc oxide at 14.4 pounds per acre gave a mean increase of 13.1 bushels in the 4-year period that it was used; a zinc chelate at 6.5 pounds per acre, but used only one year, gave no increase in yield. In Vancouver, British Columbia, the drill applications of zinc sulphate and zinc acetate resulted in gains of 46.7 and 30.0 bushels, respectively. In no case were the increases statistically significant.

Yield data over a 6-year period at Charlottetown showed that seed pieces soaked for two minutes in 0.08N solutions of zinc sulphate and zinc acetate produced significantly higher yields than seed pieces soaked in

distilled water or in 0.08N solutions of the hydrogen counterparts of the salts. In a co-operative trial in 1956, the zinc seed piece treatments resulted in increased yields in Prince Edward Island, Manitoba, and British Columbia.

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## NEWS AND REVIEWS

# WHAT FACTORS INFLUENCE THE PRICE OF POTATOES[1]

FRANCIS P. PUSATERI[2]

The popular question: "What causes the price of farm products, and the return to their producers, to fluctuate so radically from one season to another?" can quite naturally be prefaced by another question: "What factors influence the price of farm products?". And this question, on a strictly academic basis, might be answered in just two simple words—"Supply and Demand".

We have developed what we consider to be seventeen of the more important factors which help to create and influence a price structure in the potato market and they can readily be applied to most other farm products. In theory, this number could very possibly total 170 or even 1700, but we will use the seventeen we have selected and endeavor to develop each of them to a fuller understanding.

In considering the so-called "major factors", it is necessary to picture them as operative during every period involved in producing a crop, *i.e.*, during pre-planting, planting, growing, harvesting, shipping, transit and storage. Also, the factors are simultaneously active in several specific areas. In our case, Kern District, California, is in competition with (and therefore interacting with) other areas in the United States where both new stock and old stock potatoes exist at the time of our harvest. To restate the general theme briefly, we will discuss in this article the major factors during specific periods in both local and competitive areas. (See Chart.)

Our seventeen major factors are as follows:

1. *Per capita* consumption, both fresh and non-fresh.
2. Crop forecasts.
3. Rumors.
4. Acreage and yield.
5. Weather conditions.
6. Quality.
7. Size and type of container.
8. Sales and merchandising ability.
9. Daily shipments, or daily terminal market holdings.
10. Proportion of sold and unsold shipments in transit.
11. Inventory stocks at shipping points, in-transit points and receiving points.
12. Research
13. Promotion and advertising.
14. Transportation costs.
15. Time element in distribution.
16. Price spread in distribution.
17. General economic conditions.

1. *Per Capita Consumption.*

It is interesting to note that the total *per capita* consumption of potatoes in the United States has dropped from 121 pounds in 1940 to 101

[1]Accepted for publication June 26, 1958.

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pounds in 1956. This has happened despite the fact that the consumption of processed potatoes has increased from only 1.9 pounds per person to 23.4 pounds over the same period. This trend holds true for several other farm products as well. Back in1940, 65 per cent of the potato crop was consumed fresh in the home, whereas in 1956 only 40 per cent was consumed in this manner. In 1940 there was no processing of frozen french fries whatever—but in 1956, 9 million bushels of potatoes were used for this product. Potato chips in 1940 were being processed at the rate of 4½ million bushels per year—in 1956, ten times that quantity, or 45 million bushels, were consumed as chips.

A spokesman for the U. S. Department of Agriculture recently emphasized that processing of potatoes is rapidly becoming more of a factor in production and distribution. The housewife not only spends considerably less time in the kitchen than in past days, but she expects even further savings of time in meal preparation. An increasing amount of foodstuffs reaching the grocers' shelves is "pre-something-or-other": "pre-peeled", "pre-sliced", "pre-cooked"—just about everything but "pre-digested". The paring knife is rapidly disappearing from the American kitchen. Speaking of potatoes, the USDA spokesman further indicated that he anticipated the day when only premium potatoes, such as fancy bakers, would go to market in fresh form, and some measure of processing would apply to the rest.

Processing methods to alter fresh potatoes now result in frozen french fries, frozen patties and baked potatoes, chips, flakes, granules, flour, starch, *etc.* Dehydrated mashed potatoes from flakes and granules are a recent development. They have a very definite appeal to the homemaker since they represent a tremendous saving in time and effort to prepare one of America's favorite dishes—mashed potatoes.

2. *Crop Forecasts.*

Unlike most other crops, potatoes are grown in every state of the union and are being harvested in some part of the country during every month of the year. The 1950 census revealed that a total of 1,650,000 farms reported production of potatoes in the United States. In order to keep this widespread national industry informed concerning the indicated acreage, yield, production and inventories, the U. S. Department of Agriculture issues this information in the form of statistical reports on the tenth of each month. The national potato industry, as a whole, has come to rely on this reporting system as a means of gauging its activities. Other produce industries, too, consult government reports as a guide. These reports, however, have not yet been developed to 100 per cent efficiency and certain inadequacies appear from time to time. For instance, there seems to be some evidence at the present time that recent government inventory figures on potatoes, as well as indicated yield figures for Kern District's "group", called the "Late Spring States", may not have been as accurate as could be desired. Such things can readily influence the price of a perishable commodity.

3. *Rumors.*

Strange as it may seem, rumors concerning certain factors influencing the produce industry—such as inventory figures, weather conditions, and the like—play a large part in the price structure for these commodities. This potato season, for instance, reports were very prevalent that the supplies of storage stocks, particularly in the states of Maine and Idaho, were relatively low and that adverse weather conditions would cause meager production of potatoes in Florida and Alabama, another competing area. These rumors caused an artificial upsurge in the price of potatoes in the late storage areas, as well as excessively high future prices for potatoes on the New York Mercantile Exchange. As the true supply picture became evident, prices tumbled from an unrealistic high to equally unrealistic lows—which is generally the case with a perishable product.

4. *Acreage and Yield.*

Despite a greatly reduced national potato acreage over the past twenty years, fewer potatoes have not been the result. On the contrary—total production has been all the market could bear, and in many seasons, a great deal more. This has been true of many other farm products. Increased yields have been brought about by a variety of practices, such as the elimination of low-yielding acreage, specialized farms, new varieties, wide use of certified seed, more efficient control of insects and diseases, and widespread use of improved irrigation and fertilizing methods.

Perishable commodity prices are extremely variable from one season to another, as well as within the same season. For example, during the twenty year period from 1920 to 1939, the smallest potato crop (1925) had a production value of \$505,000,000.00, whereas the largest crop (1928) had a value of only \$223,000,000.00. In these twenty years the 3 smallest potato crops averaged 314 million bushels with an average value of \$433,000,000.00, and the three largest crops averaged 416 million bushels with an average value of only \$226,000,000.00. These figures emphasize the inelasticity of the demand for potatoes, which is also true in many other farm products. Growers will generally receive less total money for a large supply than for a small supply.

In the case of potatoes, analysis during recent years seems to show that there is a current market demand for approximately 25 million bushels of potatoes per month for food purposes. Prices within a season tend to go up or down as offerings increase or decrease from this amount. No one has yet been able to develop a correlation among the various factors affecting prices with sufficient accuracy to be of much value in trading—at the time the trading is being done. As a rule of thumb, the USDA indicates that a 1 per cent change in production of potatoes from the average will cause an approximate 3 per cent to 4 per cent change in price in the opposite direction—when other factors affecting prices remain constant. This means that a 5 per cent to 10 per cent change in production can cause extremely high or low potato prices.

5. *Weather Conditions.*

The factor of weather is considered in terms of temperature and precipitation, which may cause certain producing areas to harvest their

crops early, late, or at a normal calendar period. The 1958 Late Spring potato areas furnished some good examples of this influence. Abnormally low temperatures and excessive rainfall in Alabama and Florida resulted in their potato harvest being 3 to 4 weeks late, while in California, relatively normal temperatures with excessive precipitation during the planting and growing season, caused our harvest to be about ten days earlier than normal, but resulted in unusually poor yields. These poor yields were caused by the leaching out of fertilizer, the inability to properly cultivate fields during the rainy periods, compaction of soil, resulting in hard crusting of the surface which made penetration during irrigation ineffectual, planting of seed in extremely heavy soil, *etc*. Weather, of course, is an ancient and well-known friend or foe of the farm producer.

6. *Quality.*

According to the United States Department of Agriculture, one of the most significant truths turned up during the years the Perishable Agricultural Commodities Act (PACA) has been in force, is that good quality creates business and poor quality destroys it. Considering potatoes in particular, inferior quality increases risks and cuts down not only profit but range of outlets. In produce channels, poor quality tends to act as a deterrent to trade and increases the incidence of complaint under the PACA. The USDA frankly states that it is unwise to gamble on low grade or inferior potatoes. Naturally, this applies to any product, but in potato transactions especially, in a buyer's market, quality means more than in any other type of transaction.

Customers have good memories. With an increasing volume of produce on the market, they will be able to trade more and more where they are pleased, rather than simply where they are able to obtain the product. A survey by the USDA reveals that household consumers rate quality first, size second and price third when they purchase potatoes. Appearance and cleanliness are more important than price in the mind of the consumer.

7. *Size and Type of Container.*

The past thirty years has seen a gradual evolutional change in the use of various types of containers for perishable products. In the case of potatoes, years ago oversize burlap bags were filled with unwashed potatoes. When filled they weighed anywhere from 90 to 110 pounds. At another early period, unwashed potatoes were packed in wooden barrels at a weight of 165 pounds. These containers eventually gave way to 100-pound burlap bags, filled with clean washed potatoes. More recently 50-pound bags have been used. Very common these days are the 10-pound consumer packages made of mesh, paper or polyethylene. A very recent innovation for potatoes is the 50-pound carton, which lends itself to a high quality, well-shaped potato and a minimum of bruising in transit. It can readily be seen that container size and type may have a decided effect on price, not only as a result of the container cost itself, but because of resistance or acceptance factors in the market.

8. *Sales and Merchandising Ability.*

Salesmen in the potato business are often referred to as being one of two types:

Type 1: The uniformed "weak sister" variety, with no bookings, no enthusiasm, plenty of car numbers— just waiting for the phone to ring or a buyer to appear, and

Type 2: The fully informed man, with lots of enthusiasm. Always booked ahead, constantly contacting the proper outlets, offering appropriate merchandise according to grade, size and container, and making sales in line with his customers' needs at higher prices, but always in keeping with supply and demand.

Some of the basic fundamentals for selling, merchandising and distributing potatoes are universally considered to be as follows:

a. Whenever possible, book order ahead on either a "firm" or "S.A.P." basis—in advance of loading.

b. Avoid loading more shipments than can reasonably be sold on advance bookings.

c. Avoid indiscriminate consignments, to be handled "for our best advantage".

d. Avoid arrival of "rollers" at major terminals.

e. Pack several brands of the same grade with varying degrees of quality.

f. Size and grade according to premium and select packs.

g. Protect the broker, distributor or receiver in handling a brand exclusively in a certain territory.

h. Quote as accurately as possible on grade, size, maturity and condition.

i. Keep well informed on all pertinent factors daily, such as: local and national weather conditions; national rail and truck holdings; arrivals, unloads, *etc.*; local, national and international supply outlook on both an immediate and a sixty-day basis; supplies going into channels other than fresh table use; the latest USDA production, yield and acreage figures. Working in the dark hurts the individual as well as the industry.

j. Repeatedly check the integrity, business ability and financial responsibility of buying and selling connections.

k. Never under-quote or over-quote the market.

l. Keep in constant contact with the supply and demand picture in competing areas, as well as at receiving points.

m. Pack "well within" tolerance and don't try to crowd a grade to the full limit of tolerance. Packing "well within" gives some leeway for variations if inspected at receiving point.

n. Protect cash track sales by quoting and negotiating with the appropriate price differentials on "delivered" basis.

o. Specify and insist on federal inspection at receiving point in the event of disputed or "trouble" cars.

p. Always confirm sales on a 'firm" basis, allowing no protection if price advances.

q. Keep buying and selling connections fully informed about "rollers" for sale, but do not release control until sale is confirmed.

Most of these fundamentals apply to every perishable commodity. All good salesmen and brokers know and practice them. Those who do not, can adversely affect the price of a commodity.

9. *Daily Shipments.*

One of the factors that intrigues and occupies the attention of economists on the subject of short term potato price structure is the daily shipment figure. Many experienced observers have set up a formula expressing the opinion that 7500 carlot shipments, by rail and truck, per week is the approximate maximum to return a parity price. Or, expressed another way, approximately 1200 carlot equivalents in track holdings at terminal markets on any given day is an ideal figure.

10. *Proportion of Sold and Unsold Shipments in Transit.*

Short term market trends can easily be disrupted in either direction by the proportion of sold or unsold shipments that are in transit.

11. *Inventory Stocks.*

The supplies of any perishable product that exist at shipping point, at in-transit points and at receiving points greatly influence the price received for that product. In the case of potatoes, national inventory figures are generally considered to comprise fall potatoes from the 26 Late States that are in storage at production points on certain specific dates, these being December 1, January 1, February 1 and March 1. These figures are released on the tenth day of each of these months by the USDA crop reporting service. For practical purposes, however, it should always be borne in mind that stocks of these fall potatoes (which compete with our own Kern District production) also exist at various "in transit" points where cold storage facilities exist, as well as at receiving point storages in various terminal markets throughout the United States. These storages are not considered in the government reports. It is pretty generally agreed that during the 1958 Late Spring potato shipping season, supplies of old potatoes at in-transit and receiving points were ignored, until the supply picture actually made itself known in the form of depressed potato prices throughout the country.

12. *Research.*

Always vital to the production, marketing or utilization of any agricultural product are the research programs conducted. In farm crops, research is endless and covers many fields. It is a slow but steady process and results are many times routine, sometimes spectacular, but always important. Agricultural research covers such matters as variety improvement, development of alternate varieties, irrigation management, fertilizer use, soil management, weed control, growth regulators (such as the currently publicised gibberellic acid), weather influences, specific diseases and problems, new methods of harvesting, machinery to eliminate old problems, transportation services, storage factors, market surveys involving consumer, wholesaler and distributor acceptance and resistance factors, economic analyses, price spread studies, freight rate structures, development of nonfood products (commercial and industrial uses), and development of new processing methods and products. The results of research in such fields as these will ultimately affect the price structure by shifting the supply and demand picture.

13. *Promotion and Advertising.*

The average annual value of the national potato crop at the farmer's gate for the past several years has been estimated at about $500,000,000.00. The average value at the retail level is estimated to be about $1,000,000,-000.00. Many industries set aside approximately 2 per cent of the retail value of their product for promotion, so it can readily be seen that the potato industry, at the production level, should allot some $10,000,000.00 annually for advertising and promotional purposes. In contrast, approximately $750,000.00 was used by the national potato industry for the promotion of its product in 1957. This represents less than one-tenth of the amount that good business considers adequate for a normal job of advertising.

The state of Idaho is a classic example of good potato promotion. "Idaho Russet" is a household word throughout the United States and in many parts of the world. A few years ago we met a potato producer from South America who was under the impression that "Idaho" was a potato variety. That is what adequate promotion can do.

Our national potato industry, including California and Idaho, has many talking points on which to base a well-rounded promotional campaign in an effort to increase the *per capita* consumption of our product. Other farm products might adapt some of these ideas to their own use.

Emphasis on the fact that a medium-size potato contains only about 90 calories, has a beneficial amount of trace minerals and contains a generous supply of ascorbic acid (Vitamin C) could be used as a focal interest for some time by an advertising program. Speaking of Vitamin C, a white potato contains 91 milligrams of this valuable substance per pound, compared to 224 milligrams in a pound of oranges, which are popularly conceded to be the best source of Vitamin C. There is 40 per cent — or almost one-half as much ascorbic acid in a potato as in an orange.

Are potatoes fattening? Many people still think so, but if we compare the caloric content of a few foods, we find that potatoes are very low on the list.

| | | |
|---|---|---|
| For instance: | One medium baked potato | 90 calories |
| | Two pats butter | 100 |
| | One cup boiled green peas | 111 |
| | One-inch cube of cheese | 113 |
| | One large apple | 117 |
| | Two slices white bread | 126 |
| | One cup whole milk | 166 |
| | One ounce fried bacon | 173 |
| | One cup white rice, boiled | 204 |
| | One cup macaroni, boiled | 209 |
| | A two-egg omelet | 212 |
| | A halibut steak, broiled | 228 |
| | One-half avocado | 279 |
| | One hamburger patty (3 oz.) broiled | 316 |

In addition to misconceptions about potatoes, our industry has other facts that will bear promotion. At a recent conference of the National Potato Council it was revealed that increased consumption of potatoes

might be instrumental in helping PREVENT heart disease, ulcers and other maladies whose occurrence in the American people has increased in approximately the same proportions as the consumption of potatoes has decreased. Also, there are "straws in the wind" on the subject of the medicinal properties of fresh white potatoes, used as food in prescription quantities to combat malignancies and allergies. No one can comment yet with authority on this phase of potato nutritional qualities, but we believe the future will bring ever-widening realization of the highly beneficial nature of potatoes in the modern diet. It is easy to see the influence on price that a well-rounded advertising and promotion program could have.

14. *Transportation Costs.*

In considering net returns for any product it is necessary to give serious thought to the cost of transporting that product to its market. For all California agricultural products the freight rate trend to eastern population centers is steadily rising. Kern District's competing southeastern potato producing areas have freight costs aproximately 40 per cent or 50 per cent lower than our northwestern and southwestern territories. When transportation costs reach a certain level, some producing areas are automatically prohibited from reaching far-away consuming centers, except on a luxury-product basis—supplying a specialty item for those few who are interested in paying a high price.

15. *Time Element in Distribution.*

Potatoes, one of California's many crops, can be delivered by the producer to the consumer's table in from a few hours to three weeks, depending on the distance to be transported and subsequent wholesale and retail distributive channels through which they must pass. Naturally, these discrepancies in time have various effects on quality and supply, which, in turn, has a serious influence on price.

16. *Price Spread in Distribution.*

Marketing charges cover the many services required to move, process, and distribute a farm product from grower to consumer. As part of the marketing process, for instance, potatoes are washed, graded, packaged, transported to market centers, unloaded, sold several times, and repacked, before being displayed for the consumer. As labor, material and transportation costs rise, the price spread between consumer and producer becomes wider and wider, thus having a direct influence on the ultimate price of the product.

17. *General Economic Conditions.*

Some experts seem to hold the opinion that the general economic conditions of the country as a whole has a direct bearing on the price structure for farm commodities. Earlier this season, when our economic outlook appeared to be on a somewhat lower level than it is at present—due, in part, to the curtailment of income in some manufacturing operations such as automotive and aircraft—it was reasoned that certain consumers diverted their attention from the so-called luxury foodstuffs to less expensive items such as potatoes. Abrupt changes in the trend of consumer desires seem to have an influencing effect, just as sudden drops in tempera-

ture in densely populated areas tend to stimulate the consumption of more substantial foods such as potatoes.

## SUMMARY

We have outlined here what we consider to be some of the prime factors influencing the price structure for farm products. As noted at the outset, all of these factors operate during specific periods of storage, pre-planting, planting, growing, harvesting, shipping and transit, in not only the local area but in competing areas. In Kern District we find that these factors are operating during these periods in at least five competitive potato states with old stocks, namely Maine, Idaho, Colorado, Minnesota and North Dakota, and in twenty-four competitive states with new stocks. The results of this complex interplay of factors during certain periods in certain areas, finally results in a price structure.

Recognizing and properly interpreting and applying the various facts discussed in this article is a never-ending process. Psychological factors which defy quantitative measure are also involved in marketing any perishable commodity. We trust that our treatment of the subject, although not considered from a strictly academic standpoint, will enable the reader to have a clearer conception of what is involved in those factors that influence the price of farm products.

# DIPLOID PLANTS IN A SEEDLING POPULATION OF THE CULTIVATED POTATO

D. C. Cooper and G. H. Rieman[1]

The cultivated potato is a tetraploid (2n = 48). Diploid plants have heretofore been obtained following interspecific matings, using the potato as the pistillate parent and diploid tuber-bearing Solanum species as the staminate parent. When it was realized that stomatal size and number of stomata per unit area might be used as criteria for recognizing the diplids, numerous seedlings developing from seeds produced following self-pollination between selected lines of the cultivated potato were checked. All the seedlings were more or less similar morphologically.

A mature leaf was removed from each plant, the lower epidermis stripped off, mounted in aceto-carmine and examined with a microscope using a 20x ocular and a 4mm objective. The average number of stomata per unit area in most plants was fairly constant (180-190 in 25 areas) and their size varied within definite limits. In four instances the number of stomata (360-375 in 25 areas) was twice that usually present and the size was reduced to such an extent that the largest stomata approximated the size of the smallest of those from leaves of sister plants and from leaves of commercial varieties such as Katahdin and Red Warba. Fifty stomata were measured in each instance. The average size of the stomata from each of the four plants was $29\mu$ x $23\mu$ whereas the means of those from sister plants and the cultivated varieties was $38\mu$ x $27\mu$. The epidermal cells were likewise reduced in size which accounts for the greater number of stomata per unit area.

Three of the plants with small stomata have been examined cytologically and all are diploids (2n = 24). Such plants are of particular interest to the plant breeder. The chromosome number may be doubled by applying colchicine to young sprouts of a tuber during incipient stages of development. Where chromosome doubling takes place the plants produced will be approximately homozygous, a condition that can be approached only in a tetraploid after many generations of inbreeding.

Diploid and tetraploid lines within other genera have been examined and similar differences in stomata size and number occur. The technique for detecting such aberrant forms is a relatively simple one and many seedlings can be checked where it is desired to obtain diploid segregates from the progeny of a tetraploid species. Undoubtedly many such plants have been grown by potato breeders and since they probably produced smaller tubers when compared with those from sister plants and few, if any, seeds following cross pollinations within the breeding program, were discarded.

[1]Department of Genetics, University of Wisconsin, Madison, Wis.

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## MAN-KILLING RADIATION HAS NO EFFECT ON NEMATODES

Nematodes — minute worm-like parasites of plants — are unexpectedly resistant to radiation, tests by U. S. Department of Agriculture scientists reveal.

The golden nematode can withstand radiation up to 20,000 roentgens before the females are sterilized. (A roentgen is a standard unit of radioactivity.) It takes 120,000 roentgens or more to kill this plant parasite. Some other kinds of nematodes require between 350,000 and 640,000 roentgens for a lethal dose.

By comparison, the dosage considered invariably lethal to man is 650 roentgens. Some human fatalities may occur from exposure of as little as 300 roentgens.

Since nematode-killing doses of radiation will injure plants, there is no prospect that radiation can be used for killing the pests on living plants. Scientists hoped that nursery stock now being quarantined to prevent the spread of plant-parasitic nematodes to non-infested areas could be freed of the pests by exposing them to radiation.

Experiments were started two years ago in USDA's Nematology Laboratory at Beltsville, Md., and at the Brookhaven National Laboratory on Long Island, N. Y., to find whether rays from radioactive materials could be used to destroy nematodes on soil and on plant material.

The scientists also hoped to find a practical method of killing nematodes on potatoes grown in nematode-infested soil. Movement of potatoes grown on these soils at present is restricted due to the fear of spreading the nematodes if these potatoes are used for seed on non-infested land.

## EUROPEAN POTATO JOURNAL

Copies of the European Potato Journal, official publication of The European Association for Potato Research, have been received by your editor and in our estimation it compares favorably with our best scientific journals. The editor, Dr. W. H. de Jong, Wageningen, The Netherlands, is to be congratulated on the fine appearance and the well balanced subject matter in the issue.

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Send all correspondence regarding the Journal to Dr. W. H. de Jong, P. O. Box 20, Wageningen, The Netherlands.

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## DUTCH POTATO ATLAS

A publication describing the characteristics of the important varieties of potatoes grown in The Netherlands. The varieties are beautifully illustrated in color and assembled, in loose-leaf form, in a plastic cover so that descriptions of new varieties may be added as they are issued.

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